Example 2a: Bodner-Partom Viscoplastic Constitutive Model

This example problem generates the room-temperature tensile stress-strain response of the monolithic constituent materials within the MAC/GMC 4.0 internal material database that are associated with the Bodner-Partom viscoplastic constitutive model. The input file is similar to that employed in Example 1c, with changes associated with the constituent materials. As in Example 1c, this problem examines the response of monolithic inelastic materials and employs an applied strain rate of 10^{-4}/sec.

MAC/GMC Input File: **example_2a.mac**

```
MAC/GMC 4.0 Example 2a - Bodner-Partom Viscoplastic Constitutive Model
*CONSTITUENTS
  NMATS=7
# -- Al 2024-T4
  M=1 CMOD=1 TREF=23. MATID=A
# -- Al 2024-0
  M=2 CMOD=1 TREF=23. MATID=B
# -- Al 6061-0 (a)
  M=3 CMOD=1 TREF=23. MATID=C
# -- Al 6061-0 (b)
  M=4 CMOD=1 TREF=23. MATID=D
# -- Al pure
  M=5 CMOD=1 TREF=23. MATID=E
# -- Ti pure
  M=6 CMOD=1 TREF=23. MATID=F
# -- Cu
  M=7 CMOD=1 TREF=23. MATID=G
*RUC
  MOD=1 M=1
#  MOD=1 M=2
#  MOD=1 M=3
#  MOD=1 M=4
#  MOD=1 M=5
#  MOD=1 M=6
#  MOD=1 M=7
*MECH
  LOP=1
  NPT=2 TI=0.,200. MAG=0.,0.02 MODE=1
*SOLVER
  METHOD=1 NPT=2 TI=0.,200. STP=0.025
*PRINT
  NPL=6
*XYPLOT
  FREQ=10
  MACRO=1
   NAME=example_2a X=1 Y=7
  MICRO=0
*END
```

Annotated Input Data

1) Flags: None

2) Constituent materials (***CONSTITUENTS**) [KM_2]:

Number of materials:	7	(NMATS=7)
Constitutive model:	Bodner-Partom	(CMOD=1)
Materials:	Al 2024-T4, Al 2024-0, Al 6061-0 (a), Al 6061-0 (b), Al pure, Ti pure, Cu	(MATID=A-G)
Reference Temperature:	23. °C	(TREF=23.)

3) Analysis type (***RUC**) → Repeating Unit Cell Analysis [KM_3]:

Analysis model:	Monolithic material	(MOD=1)
Material assignment:	Each constituent successively	(M=1-7)

☞ Note: Each material in ***CONSTITUENTS** is assigned to the monolithic material successively by commenting and uncommenting the appropriate lines for separate executions of the code.

4) Loading:

a) Mechanical (***MECH**) [KM_4]:

Loading option:	1	(LOP=1)
Number of points:	2	(NPT=2)
Time points:	0., 200. sec.	(TI=0.,200.)
Load magnitudes:	0., 0.02	(MAG=0.,0.02)
Loading mode:	strain control	(MODE=1)

b) Thermal (***THERM**): None

c) Time integration (***SOLVER**) [KM_4]:

Time integration method:	Forward Euler	(METHOD=1)
Number of time points:	2	(NPT=2)
Time points:	0., 200. sec.	(TI=0.,200.)
Time step size:	0.025 sec.	(STP=0.025)

☞ Note: A very small time step size is employed in this example (0.025 sec.) compared to that used in Examples 1c and 1d, which employed the isotropic GVIPS constitutive model (1. sec.). The smaller time step required for convergence of the forward Euler integration scheme is due to the numerically stiff nature of the Bodner-Partom model equations. A smaller time step is directly associated with increased execution time, thus, in many cases it is preferable to employ the alternative time integration method, the predictor-corrector (METHOD=2) when utilizing the Bodner-Partom model as this integration scheme allows for a variable time step. See Example 4h, which employs this predictor-corrector method, for more information.

5) Damage and Failure: None

6) Output:

a) Output file print level (***PRINT**) [KM_6]:

Print level: 0 (NPL=0)

☞ Note: A print level of 0 results in minimal output being written to the output file.

b) x-y plots (***XYPLOT**) [KM_6]:

Frequency:	10	(FREQ=10)
Number of macro plots:	1	(MACRO=1)
Macro plot name:	example_2a	(NAME=example_2a)
Macro plot x-y quantities:	ε_{11}, σ_{11}	(X=1 Y=7)
Number of micro plots:	0	(MICRO=0)

7) End of file keyword: (***END**)

Results

This example problem illustrates how MAC/GMC 4.0 can be used to quickly generate the response of the materials within the internal material database. By altering the materials in ***CONSTITUENTS**, the user can use the example 2a input file to generate the response of other materials within the code's internal material database at any temperature desired.

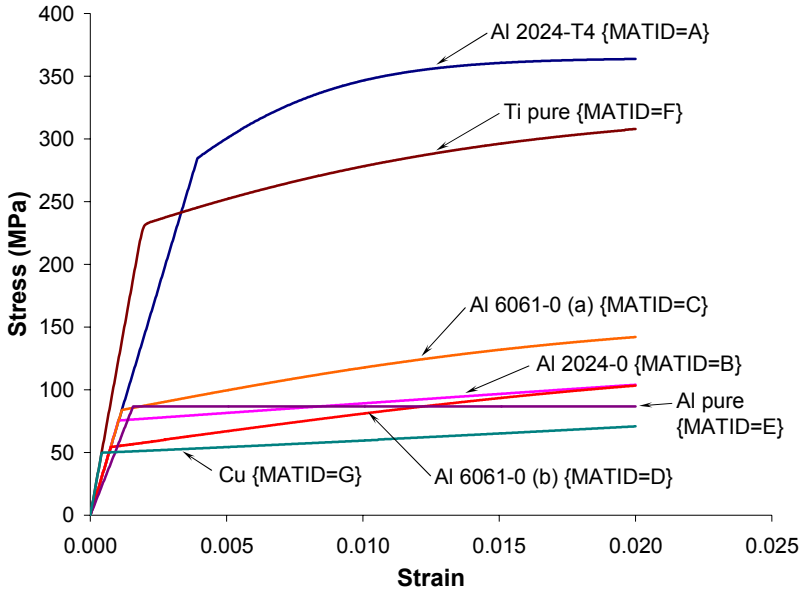

Figure 2.1 Example 2a: plots of the room-temperature tensile stress-strain response of the seven materials within the MAC/GMC 4.0 internal material database that are associated with the Bodner-Partom viscoplastic constitutive model.